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Evaluation of Airborne Dust Concentration And Effectiveness of Cooling fan with Spraying Misting Systems in Swine Gestation Houses

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EVALUATION OF AIRBORNE DUST CONCENTRATION AND EFFECTIVENESS OF COOLING FAN WITH SPRAYING MISTING SYSTEMS IN SWINE GESTATION HOUSES

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ABSTRACT

Airborne dust in swine houses can cause serious health problems for humans as well as for animals. The aim of this experiment was to evaluate the airborne dust concentration range and effectiveness of cooling fan with spraying misting systems in the gestation houses in the management practices of China. The experiment was implemented in a gestation barn housed 239 gestation pigs in Hebei Province of China. The tests showed that the average airborne dust concentration was about 4.70 ±3.24 mg/m^3 in cold weather and 2.18 ±1.61 mg/m^3 in warm weather, respectively. The high dust concentration of 17.55 ± 1.18 mg/ m^3 in winter and 15.25 ± 1.77 mg/m^3 in summer happened in the feeding period. When the misting cooling system with droplet diameter of 20-50 μ m turned on, the average airborne dust concentration could be reduced by 75%, from 7.94 ±4.67 mg/m^3 to 1.98 ±1.80 mg/m^3, during the feeding period.

KEYWORDS. Airborne dust, concentration, spraying, swine

INTRODUCTION

Pig farmers have a high prevalence of wheezing and symptoms of chronic bronchitis (Dosman et al., 1987). Work in pig houses is associated with an acute decrease of the lung function (Iversen and Takai, 1990). Organic dust in the air of livestock buildings consists of grain and other plant-derived particles, animal-derived dander, hair, urine, excrements, microorganisms, and particles. The dust sources are feed, animal, manure, insects, and microorganisms. Dust particles may carry hazards such as pathogenic bacteria, viruses, endotoxins or other organic substances (Bækbo, 1989).

Total dust concentrations are usually in the range of 2 to 5 mg/m$^{3\ but}$ may range as high as 10 to 20 mg/m^3 (Donham et al., 1986). Dust concentrations depend on several factors including animal activity, ventilation rate, feeding practices, bedding, and manure handling, and feed is one of the main dust sources. The previous studies concluded that approximately 8% particle shapes were skin, 1% were hair, and remaining 91% were attributed to feed (Pearson et al., 1995). So, dust concentration is largely related to the management practices.

China is one of the biggest pork producers in the world; the dust related wheezing disease is a big challenge. However, the field experiment on quantity of dust concentration and study on dust-control technologies in China specific pig production system is limited. The objective of

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this study was to measure the airborne dust concentration variety on both a daily and seasonal basis, to identify major contributor to the total dust emission, then to test the effectiveness of spraying misting on reducing total dust concentration.

MATERIALS AND METHODS

Description of Experimental Swine Gestation Facility

The experiments were conducted in a swine gestation house at an experimental farm in the Hebei Province of China, experiment dimensions are shown in Figure 1.

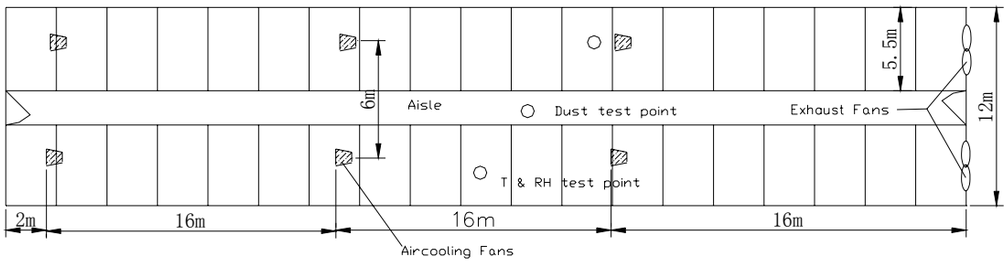

Figure 1. The plan of experiment gestation house

The dimensions of the experimental house were 50 meters length by 12 meters width with a west-east orientation. There were two exhaust fans with air capacity of 45000m^3/h at 2-4 mm H_20 in the east side wall. There were six cooling fans with air capacity of 4800 m^3/h at 2-4mm H_20 in the house, the cooling fans were installed in two rows of three fans evenly spaced with 16 meters between fans in length and 6 meters between fans in width, the installed height was 2.2 m above the floor. The spray water capacity of cooling fan was 80l/h, spraying droplet diameter was about 20-50 μ m, and the spray water volume was about 2 L per animal per hour. In summer, the barn was ventilated by the exhaust fans and cooling fans continuously. The control unit with programmable timers provides automatic spraying at preprogrammed spraying times and intervals. The spraying system was inactivated when the indoor temperature was below 28°C, once the inside temperature reached 28 °C both the cooling fan and its fogging system would turn on. In the winter season, the 2 exhaust fans operated 15 minutes every 4 hours to provide fresh air, and all the windows were closed to keep the inside temperature comfortable.

There were 239 gestation pigs of 210–250 kg live weight in the house during test period. The feeder contained dry powdery feed, consisting of approximately 80% ground grain, mainly corn and wheat, and roughly 16% protein. They were fed twice a day, at 4:30 am and 4:00 pm. The pens were cleaned at 5:00 am after feeding time in the morning and 3:50 pm before the feeding time in the afternoon. The manure in the pen was swept into the gutter and then was flushed out of the building.

Measurements

The dust concentration samples were taken at 1-h intervals for three days in January 2003, July and August 2003, and April 2004. Total suspended particle (TSP) was determined using gravimetric measurement methods. The dust sampler used was a double air channel and timer dust sampler (model: DS-21, China). Total dust was sampled using a 40 mm glass fiber filter. Sampling inside the barn was done at the center aisle, 1.5 m above the floor. Sampling rate for total dust analysis was 20 L/min, and running time was 20 minutes per hour. The weight of the filter membrane was measured before and after sampling using an electronic balance to measure the membrane weight (Precision: 0.1mg, Sartorius AG, Germany) in a controlled environment room, before weighting, the dust samples were kept in the same rooms for acclimatization for eight hours.

The indoor temperature and relative humidity were measured at 1.5 m above the floor in the center of the rooms. The average values for the same time period as the stationary dust sampling

were determined and recorded with portable Temperature/RH loggers (HOBO Pro RH/Temp, Onset Computer Corporation, USA). The outdoor temperature and relative humidity were sampled 2 m downwind from the sidewalls. The measurement readings for indoor and outdoor temperature and humidity were taken at 1-h intervals.

RESULTS AND DISCUSSION

Variation of Airborne Dust Concentration

Figures 2 and 3 show the airborne dust concentration variation in the gestation house over more than 3 continuous days in different seasons. The airborne dust concentration varies from 0 to 17.55 mg/m^3 in cold weather and 0 to 15.25 mg/m^3 in warm weather. The high dust concentrations at 4:00~5:00 AM and 16:00~17:00 PM were measured because of feeding dry powdery feed, at the same time, the activity of the pigs during feeding times leads to feces and settled dust becoming airborne dust. The minimum concentration depends on outside background dust concentration.

The average airborne dust concentrations for daytime (8:00~19:00) and nighttime (20:00~7:00) in cold weather were 4.22±3.25 mg/m^3 and 4.73±3.19 mg/m^3 respectively ; the inside average dust concentrations in warm weather were 1.98±1.61mg/m^3 for daytime and 2.43± 2.18 for nighttime, respectively ; The low level concentration in warmer season was related to the high humidity and high exhausted ventilation .

The mean airborne dust concentrations for the gestation barn under experiment conditions were 4.70±3.24 mg/m^3 in January, 4.24±3.26 mg/m^3 in March, 2.20±2.43 mg/m^3 in July, and 2.18 ±1.61mg/m^3 in August respectively (Table 1).

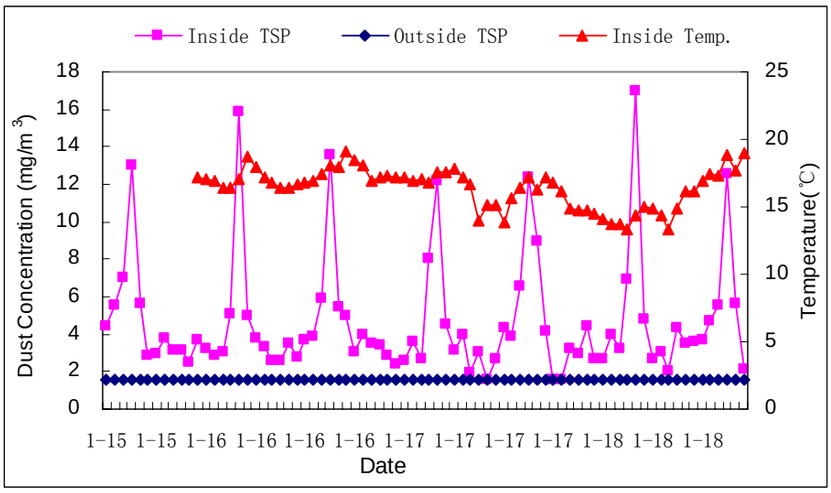

Figure 2a. Daily variation of TSP and temperature in swine gestation house in January 2003

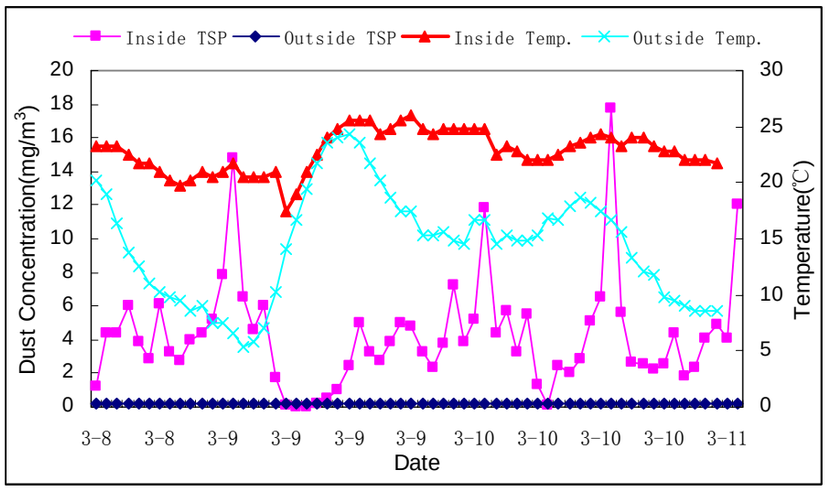

Figure 2b. Daily variation of TSP and temperature in swine gestation house in March 2004

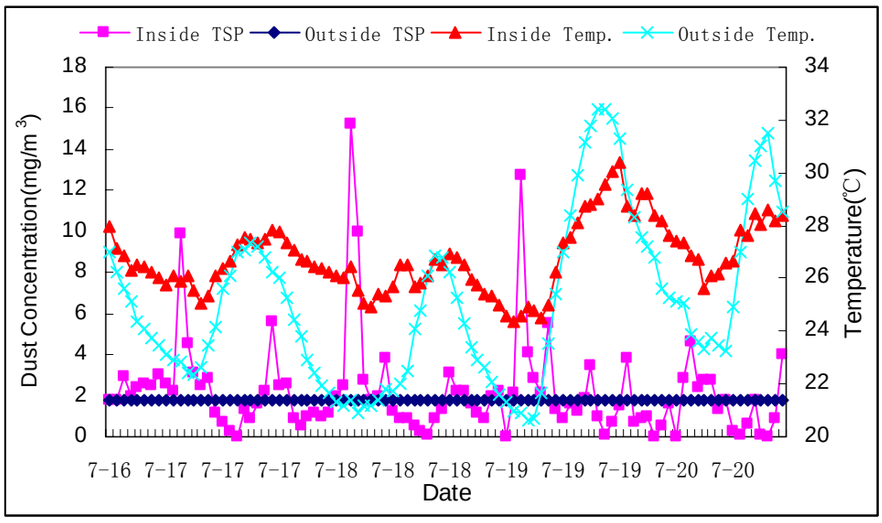

Figure 3a. Daily variation of TSP and temperature in Swine Gestation house in July 2003

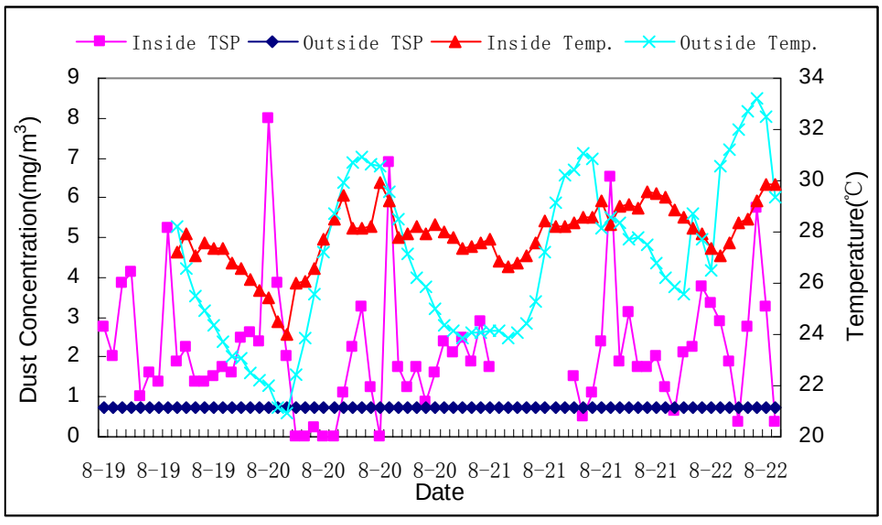

Figure 3b. Daily variation of TSP and temperature in Swine Gestation house in August 2003

Table 1. Comparison of average TSP concentration in cold and warm weather

Date		Winter				Summer			
		1/15/2003~1/18/2003		3/8/2004~3/11/2004		7/16/2003~7/20/2003		8/19/2003~8/22/2003	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Total Dust Concentration (mg/m^3)	Mean	4.70	1.60	4.24	0.00	2.20	1.75	2.18	0.75
	SD	3.24	0.91	3.26	0.18	2.43	0.00	1.61	0.00
	Max	17.00		17.75		15.25		8.00	
	Min	1.58		0.00		0.00		0.00	
Temperature （°C）	Mean	16.43	Not recorded*	22.80	14.44	26.76	25.05	27. 84	26.88
	SD	1.45	Not recorded	1.84	4.93	1.31	3.12	1.21	3.12
	Max	19.07	Not recorded	25.95	24.40	30.41	32.42	29.93	33.25
	Min	13.29	Not recorded	17.52	5.40	24.34	20.64	24.01	20.95

* The temperature did not recoded because the Temperature/RH loggers was accidentally destroyed

The Impact of Spraying Water on Dust Concentration

The low level airborne dust concentrations inside pig barn in July and August (Table 1) could be explained by spraying water. When the inside and outside temperatures were below 28 °C, the air cooling fans stopped spraying water, and the average airborne dust concentration was 7.94 ±4.67mg/m^3 during morning feeding time (4:00~5:00) in July. In the afternoon, the inside and outside temperature exceeded 28°C, the air cooling fans began to spray water, and the average airborne dust concentration was 1.98±1.80 mg/m^3 during feeding time (16:00~17:00), Spraying water resulted in 75% reduction of dust concentration. In August, the cooling fans with spraying water turned on continuously from early morning to the middle night because of high air temperature, there is no significant dust concentration differences between morning feeding time and afternoon feeding time. The average airborne dust concentration was 3.98 ±2.38mg/m^3 during morning feeding time (4:00~5:00) and 3.73 ±2.87mg/m^3 during afternoon feeding time (16:00~17:00) (Table 2). The airborne dust concentration can be reduced though spraying misting during feeding time.

Table 2. Average TSP concentration during feeding time with and without spraying water in warm weather

		July		August	
		Morning (without spray)	Afternoon with spray	Morning with spray	Afternoon with spray
TSP Concentration (mg/m^3)	Mean	7.94	1.98	3.98	3.73
	SD	4.67	1.80	2.38	2.87
Inside Temperature (°C)	Mean	25.90	27.99	26.68	28.91
	SD	0.92	1.22	1.18	0.67
Outside Temperature (°C)	Mean	22.22	28.88	24.72	29.73
	SD	1.44	2.59	3.04	1.16

CONCLUSIONS

From the results, it can be concluded that:

1. The feeding activity resulted in high dust concentration, the dust concentration of 17.55 mg/m^3 in winter and 15.25 mg/m^3 in summer happened in the feeding time.
2. Mean airborne dust concentration in gestation house was higher in cold weather than in warm weather. The average airborne dust concentration was 4.20-4.70 mg/m^3 in cold weather and 2.18-2.20 mg/m3 in warm weather.
3. The spraying misting could reduce 75% of average airborne dust concentration in summer under the experiment condition.

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